DOCUMENT RESUME

ED 151 743 CS 003 972

AUTHOR Ghatala, Elizabeth S.; And Others
TITLE Apparent Frequency of Words and Pictures as a Function of Pronunciation and Imagery. Technical Report No. 238.
INSTITUTION Wisconsin Univ., Madison. Research and Development Center for Cognitive Learning.
SPONS AGENCY Office of Education (DHEW), Washington, D.C.
PUB DATE Nov 72
CONTRACT OE-5-10-154
NOTE 15p.

EDRS PRICE MF-$0.83 HC-$1.67 Plus Postage.
DESCRIPTORS *Cognitive Processes; Grade 6; Intermediate Grades; Learning Theories; *Memory; *Pictorial Stimuli; Pronunciation; *Recall (Psychological); *Recognition; *Word Frequency

ABSTRACT

This study applied a frequency theory to measure the superiority of pictures over words in both discrimination learning and recognition memory tasks. Three groups of sixth grade students were given separate instructions before viewing slides of either common objects or words. The first group (control) was asked to study the items shown, the second group was told to pronounce each word or name of object three times, and the third group was instructed to picture each word or object in their mind. After studying either a picture or word list, the subjects were instructed to respond to each item, guessing if uncertain, by saying the number of times that the item had been presented for study. Results show that, in comparison to words, pictures were judged as having occurred more frequently, resulted in less within-subject judgments, and produced fewer misjudgments on items not presented during study. At the same time, instructions to pronounce or to picture the items during the viewing of slides had no effect on frequency judgments, either as a main effect or in interaction with differing item types. (MAI)

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Technical Report No. 238

APPARENT FREQUENCY OF WORDS AND PICTURES AS A FUNCTION OF PRONUNCIATION AND IMAGERY

by

Elizabeth S. Ghatala, Joel R. Levin, and Larry Wilder

Report from the
Operations and Processes of Learning
Component of Program 1

Herbert J. Klausmeier, Frank H. Farley
Joel R. Levin, and Larry Wilder

Principal Investigators

Wisconsin Research and Development
Center for Cognitive Learning
The University of Wisconsin
Madison, Wisconsin

November 1972

CS003972

Published by the Wisconsin Research and Development Center for Cognitive Learning, supported in part as a research and development center by funds from the United States Office of Education, Department of Health, Education, and Welfare. The opinions expressed herein do not necessarily reflect the position or policy of the Office of Education and no official endorsement by the Office of Education should be inferred.

Center No. C-03 / Contract OE 5-10-154

Statement of Focus

Individually Guided Education (IGE) is a new comprehensive system of elementary education. The following components of the IGE system are in varying stages of development and implementation: a new organization for instruction and related administrative arrangements; a model of instructional programing for the individual student; and curriculum components in prereading, reading, mathematics, motivation, and environmental education. The development of other curriculum components, of a system for managing instruction by computer, and of instructional strategies is needed to complete the system. Continuing programmatic research is required to provide a sound knowledge base for the components under development and for improved second generation components. Finally, systematic implementation is essential so that the products will function properly in the IGE schools.

The Center plans and carries out the research, development, and implementation components of its IGE program in this sequence: (1) identify the needs and delimit the component problem area; (2) assess the possible constraints—financial resources and availability of staff; (3) formulate general plans and specific procedures for solving the problems; (4) secure and allocate human and material resources to carry out the plans; (5) provide for effective communication among personnel and efficient management of activities and resources; and (6) evaluate the effectiveness of each activity and its contribution to the total program and correct any difficulties through feedback mechanisms and appropriate management techniques.

A self-renewing system of elementary education is projected in each participating elementary school, i.e., one which is less dependent on external sources for direction and is more responsive to the needs of the children attending each particular school. In the IGE schools, Center-developed and other curriculum products compatible with the Center's instructional programing model will lead to higher student achievement and self-direction in learning and in conduct and also to higher morale and job satisfaction among educational personnel. Each developmental product makes its unique contribution to IGE as it is implemented in the schools. The various research components add to the knowledge of Center practitioners, developers, and theorists.

Acknowledgment

We are grateful to Professor B. J. Underwood for providing valuable assistance in the conceptualization of this experiment. In addition, we appreciate the assistance of Nancy Hurlbut in collecting the data, and of Jan Sluga and Diane Eich in preparing the final draft of the paper.

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I
Introduction

Recognition memory for pictures has been consistently demonstrated to be superior to memory for their verbal labels (Fozard & Lapine, 1968; Jenkins, Neale, & Deno, 1967; Paivio & Csapo, 1969). Moreover, recent experiments employing verbal and pictorial discrimination learning tasks have suggested that picture pairs are easier to discriminate than word pairs (Rowe, 1972; Rowe & Paivio, 1971a; Wilder & Levin, in press). According to frequency theory (Ekstrand, Wallace, & Underwood, 1966), situational frequency is one of the principal memory attributes used in recognition memory and discrimination learning tasks. The theory posits that in discrimination learning, greater frequency accrues to the "correct" item than to the "incorrect" item in a pair because of such factors as differential rehearsal favoring the former. Thus, a subject discriminates the items in each pair on the basis of the frequency difference between them. Similarly, in a recognition memory test a subject may discriminate old from new items on the basis of the higher situational frequency of the former due to their exposure on the learning trial (Underwood & Freund, 1970).

Frequency theory can account for the superiority of pictures over words in both discrimination learning and recognition memory tasks if one or both of the following assumptions are true:

(1) Given equal presentation frequency, the average apparent frequency of pictures is higher than the apparent frequency of their corresponding verbal labels.

That is, a greater amount of subjective frequency is elicited by the occurrence of a picture than by the occurrence of a word.

(2) Given equal presentation frequency, a subject's judgments of the frequency of items are less variable on the average for pictures than for words.

That is, pictures and words may elicit the same amount of subjective frequency, but subjects may be more consistent in judging the situational frequency of pictures than in judging the frequency of words.

If the first assumption is true (and if frequency accrues to the right and wrong members of pairs in the manner stipulated by frequency theory), it should be easier to learn to choose the correct items on a discrimination task consisting of picture pairs than on one consisting of word pairs, since a larger absolute frequency difference in favor of the correct items would build up for picture pairs than for word pairs given the same number of trials. In the case of a recognition memory test where subjects discriminate old and new items on the basis of the absolute frequency difference between them, it is obvious that the assumption of greater apparent frequency for pictures than for words would lead to the prediction of better recognition for the former.

The second assumption of less variability in apparent frequency of pictures than of words also predicts better recognition and discrimination learning of pictures than words but for a slightly different reason. The less variable a subject is in judging the frequency of items which have occurred a given number of times, the better he should be able to discriminate between items which have occurred with different frequencies. Lower variability in apparent frequency of pictures would mean that while the buildup of a frequency difference between items within pairs would be equal on the average for word and picture lists, subjects would be better able to discriminate the difference in the case of picture pairs. The same argument would hold for discriminating

between old and new items in a recognition task.

In the present experiment, both of the above assumptions were tested directly by manipulating the frequency of pictures and words in the laboratory and asking subjects to make absolute frequency judgments. In addition, the effects of pronunciation and imagery on the apparent frequency of both pictures and words were of interest.

Indirect evidence from verbal discrimination studies suggests that either subject-generated vocalizations or images may increase the apparent frequency of words (Carmean & Weir, 1967; Levin, Ghatala, Wilder, & Inzer, in press; Rowe & Paivio, 1971b). In the present experiment, the effects of both types of responses on apparent frequency were directly assessed. Of particular interest was the detection of any differential effects of pronunciation and imagery on the apparent frequency of words and pictures.

II
Method

Materials

Picture stimuli consisted of 49 line drawings of common objects (e.g., shoe, clock). Of these, 39 were randomly distributed among the four frequency categories represented in the study list. The ten remaining pictures were used as filler (or zero-frequency) items on the test trial. The study list consisted of 20 pictures presented once, ten pictures presented twice, six pictures presented three times, and three pictures presented four times, thereby making a total of 70 study presentations. The order of the pictures on the study trial was random subject to the restriction that pictures with multiple occurrences were distributed equally in each equal-sized section, with the number of sections being determined by the frequency. That is, a picture presented twice occurred once in each half of the list, a picture presented three times occurred once in each third of the list, and so on. The same picture never occurred in adjacent positions. Of the 20 pictures occurring once, five were randomly assigned to each quarter of the list.

The test list consisted of the 39 pictures presented for study plus ten pictures which had not been presented. The order of the pictures on the test trial was random.

The word stimuli consisted of the 49 verbal labels for the pictures. The order of study and test items for the word conditions duplicated those of the picture conditions. The line drawings were photographed and mounted one to a slide; the words were typed one on a card in primary type, photographed, and mounted on slides.

Procedure

The pictures and words were presented for study to independent groups of subjects. In both conditions, subjects were run individually and slides were shown at a 5-sec. rate by means of a Kodak Carousel slide projector. All subjects were told that some of the items would occur more than once and that they should pay close attention because later they would be asked questions about the pictures (words). Within the picture and word conditions three independent groups of subjects were given different types of instructions before beginning the study trial. One group (control) was simply told, as above, to study the items. A second group (pronunciation) was told to say each word (or the name of each picture) out loud three times.[1] A third group (imagery) was instructed, in the case of the verbal stimuli, to "get a picture in your mind of what that word stands for." They were instructed to do this for each word every time it occurred. Subjects studying the picture stimuli were told to "get a picture in your mind of what is shown on the screen." Practice trials were given and subjects in both the picture and word conditions appeared to understand the imagery instructions.

After studying either the picture or word list, subjects were given the appropriate test list at a 5-sec. rate. The subjects were instructed to respond to each item, guessing if uncertain, by saying the number of times that the item had been presented for study.

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[1]The decision to have the subject pronounce each item three times was based on the Rowe and Paivio (1971b) procedure, and served to approximate more closely the amount of response time required in the imagery generation condition (cf. Paivio, 1971).

Subjects

The subjects were 114 sixth-grade students (mean age, 12.6 years) from an elementary school in a semirural Wisconsin community. Subjects were assigned to a block-randomized schedule of the six conditions formed by the factorial combination of stimulus mode (pictures or words) and instructions (control, pronunciation, or imagery). Nineteen subjects were thus assigned to each group. The subjects were tested individually in a small, private testing room located in the school building.

III
Results

The dependent variable for this experiment consisted of the number of times an item was judged to have occurred when presented to a subject on the test list (hereafter this will be referred to as "apparent frequency").

At each level of presentation frequency (0, 1, 2, 3, 4), two summary statistics were computed on the apparent frequencies for each subject: (a) an intra-individual mean which was the average of a subject's frequency judgments across all items with the same presentation frequency; and (b) an intra-individual variability index which was simply the variance (average squared deviation) of a subject's frequency judgments for all items with the same presentation frequency. Analyses of the subjects' means and variances were then carried out separately for items that had been presented on the study list only once, more than once, or not at all.[2] In each analysis, comparisons among the three instructional groups (control, pronunciation, and imagery) were made within stimulus types (pictures and words). Each source of variance was tested with the probability of a Type I error set equal to .05.

Apparent frequency means and intra-subject variances are summarized in Table 1.

For items presented once, analysis of variance revealed a significant effect of stimulus type on both measures, such that pictures resulted in higher mean apparent frequency than printed words (F [1,108] = 3.93, $p < .05$) and had lower intra-subject variability associated with them (F [1,108] = 8.27, $p < .005$). No simple main effects of instructional conditions were significant (all p's > .10).

Across items with two to four presentation frequencies, pictures exhibited greater mean apparent frequency than words (F [1,108] = 6.20, $p < .05$), as well as lower variability (F [1,108] = 19.00, $p < .001$). In addition, none of the effects associated with instructional conditions were significant (all p's > .10), thereby substantiating the results based on items presented only once.

Multivariate comparisons among items presented twice, three times, and four times revealed that mean apparent frequency varied with presentation frequency (F [2,107] = 273.08, $p < .001$), although the variability measure did not ($F < 1$). Once again, no effects involving instructions were significant (all p's > .05).

Until now, only the judged frequencies for items which were presented at least once on the study list have been considered. As may be seen in Table 1, however, the occurrence of "false alarms" (i.e., apparent frequencies greater than zero for items never presented) was, in general, quite low. Statistically, fewer false alarms were associated with pictures than with words (F [1,108] = 4.60, $p < .05$), the former exhibiting lower variability than the latter (F [1,108] = 13.19, $p < .001$). Although the data in Table 1 suggest that more false alarms occurred in the control than in the two other instructional conditions, none of the effects involving this factor were significant (all p's > .10).

[2] Analyses were performed on both logarithmically transformed and untransformed variances, but since the statistical decisions were identical in all cases only the results of the latter analyses will be reported.

Table 1
Average Means and Intra-Subject Variances for Various Presentation Frequencies as a Function of Instructional Conditions and Stimulus Types

Presentation Frequency	Measure	Words			Pictures		
		Control	Pronunciation	Imagery	Control	Pronunciation	Imagery
0	Mean	.12	.05	.10	.06	.00	.01
	Variance	.12	.06	.07	.01	.00	.01
1	Mean	.91	1.05	1.04	1.12	1.14	1.14
	Variance	.40	.48	.40	.34	.16	.27
2	Mean	1.73	1.87	1.87	1.90	1.99	2.05
	Variance	.74	.63	.52	.35	.32	.37
3	Mean	2.58	2.60	2.48	2.69	2.72	2.80
	Variance	.63	.57	.56	.48	.41	.44
4	Mean	3.05	2.86	3.28	3.67	3.28	3.51
	Variance	.56	.63	.61	.53	.35	.37

IV
Discussion

The results of the present study lend strong support to frequency theory. Our premise was that frequency theory could account for better discrimination learning and recognition memory for pictures than for words if pictures elicit greater subjective frequency than words or if subjects are less variable in their judgments of situational frequencies of pictures than of words. In fact, both of these assumptions were confirmed by the data. At presentation frequencies of one, two, three, and four, the mean judged frequencies for pictures were higher than for words, with the effect not varying as a function of instructions. Similarly, at each presentation frequency the variability of subjects' frequency judgments was lower for pictures than for words. The finding of fewer false alarms (in the case of items not presented on the study trial) for pictures than for words provides further evidence that subjects are better able to discriminate situational frequencies of pictures than words.

Finding the answer to the questions, "Why do pictures elicit greater subjective frequency than words?" and "Why are subjects less variable in judging frequency of pictures than words?" is a topic for further research. Our speculation at this time is that pictures or drawings of the type created for this and other experiments which employ pictorial materials, while representing common, familiar objects, are in themselves relatively novel stimuli. That is, subjects are not likely to have encountered the particular experimental pictures in the past. On the other hand, the words (or labels for the pictured objects) have probably been encountered by subjects many times in their past experience. The suggestion, therefore, is that pictures and words differ in background (or pre-experimental) frequency.

The assumption of lower background frequency for pictures than for words could account for higher mean frequency judgments for pictures and lower variability in judgments of pictures. Ekstrand, Wallace, and Underwood (1966, p. 575) suggested this possibility as follows: "The [frequency] theory might even predict (according to Weber's law) that adding one unit to an item already high in frequency should be less noticeable than adding one frequency unit to an item low in frequency." Ekstrand et al. also pointed out, however, that the application of Weber's law may not be appropriate since extraexperimental frequency may not be comparable to experimentally induced frequency. Research directed toward exploring background frequency as a variable in both learning and frequency judgment tasks with pictorial and verbal materials is currently underway.

Regardless of the underlying explanation, the finding of higher mean frequency judgments and lower variability of judgments for pictures than for words clearly indicates that the superiority of pictures over words in discrimination learning tasks and in recognition tasks can be accounted for in terms of frequency theory. Although such a "frequency" interpretation of picture-word differences does not rule out a stimulus "concreteness" explanation of the same effect (Paivio, 1971), the frequency theory is at present preferred because of its greater parsimony.

Concerning instructions to image or pronounce stimulus items during the study trial, the results were also clear-cut. Neither had significant effects on subjects' frequency judgments. The failure of subject-generated pictures (following imagery instructions) to "behave" like experimenter-provided pictures may be tentatively interpreted as follows. When a subject is instructed to image a presented word (e.g., "house"), it is likely that he will retrieve a picture from his pre-experimental repertoire, i.e., a visual stimulus with

which he is already familiar (e.g., the house that he lives in). As was noted previously, this will not be the case when the experimenter supplies the subject with a picture (regardless of whether or not the subject images it). Thus, experimenter-provided pictures have lower background frequencies (and hence, are more susceptible to Weber's law) than their verbal labels, and such differences remain relatively unaffected by instructions to use visual imagery.

A final resolution of the present data is accomplished by considering a recent experiment by Hopkins, Boylan, and Lincoln (1972). These investigators found that when pronunciation instructions were employed as a between-subject factor (i.e., all items were pronounced by one group and no items were pronounced by another group), pronunciation had little effect on apparent frequency of words. When a within-subject design was used (i.e., subjects pronounced some items but not others) apparent frequencies for pronounced items were higher than for items not pronounced. In the present experiment, instructions were given in a between-subject design and the Hopkins et al. negligible pronunciation effect was obtained. On the basis of the Hopkins et al. data for pronunciation and apparent frequency, it may be hypothesized that imagery instructions will influence frequency judgments if they are manipulated within subjects. Certainly, the facilitative effects of vocalization and imagery instructions in verbal discrimination learning (e.g., Levin et al., in press; Rowe & Paivio, 1971b; Wilder & Levin, in press)—which may be construed as a within-subject manipulation—support this prediction.

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GPO 801-847-9